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AUTHOR Braby, Richard
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ABSTRACT

A computer-aided authoring technique for generating symbol learning materials is described in which a human author enters information about a set of symbols into a data base and a computer routine merges the contents of the data base with generic formats and automatically organizes and prints a complete learning package. Three key issues discussed are (1) the training effectiveness of computer-authored training materials; (2) the cost-effectiveness of authoring materials in this manner; and (3) what can be reasonably expected from computer authoring -- currently value lies in authoring materials with high levels of redundancy. (Author/CMV)

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Technical Note 2-79

COMPUTER-AIDED AUTHORING OF INSTRUCTIONAL MATERIALS

Richard Braby

Training Analysis and Evaluation Group
Orlando, Florida 32813

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COMPUTER-AIDED AUTHORING OF INSTRUCTIONAL MATERIALS

Job training in the military is clearly a huge enterprise. For example, the Department of Defense in FY 78 provided 136,000 man-years of specialized skill training at a cost of $3.3 billion. In the Navy alone there are over 2,000 courses on the calibration, repair, and service of specific pieces of equipment. Producing job training materials for these courses is expensive, and the training effectiveness of these materials is not guaranteed since effective principles derived from training research are not fully incorporated into these materials. Without effective training materials, costly training time is wasted. Currently, the problems associated with writing and publishing instructional materials are coming under systematic scrutiny. Several large scale design efforts for the efficient presentation of technical information are underway.

One of these programs is the Naval Technical Information Presentation Program (NTIPP), a 5-year, multimillion dollar program to improve the Navy's efficiency in publishing. State-of-the-art techniques in authoring, editing, composing, typesetting, illustrating, printing, and distributing are being applied to the process of publishing Navy technical information to support the maintenance and operation of Navy equipment. This effort is managed by the David W. Taylor Naval Ship Research and Development Center with participation by other Navy activities. The Training Analysis and Evaluation Group (TAEG) represents the Chief of Naval Education and Training (CNET) in this program. The program is of special interest to CNET because the technical manuals serve as textbooks in the CNET-managed "C" schools, and the training handbooks serve as the student and instructor guides in these schools. These materials also support on-the-job training. Improved documents will result in improved training.

Within NTIPP, the TAEG is investigating the feasibility of authoring instructional materials with the aid of computers. Producing effective materials at low cost is the major goal. Our task is to design materials to teach the operation and maintenance procedures for military equipment. Initially we have developed computer routines to author materials for teaching symbol identification. We thought this would be a simpler computer authoring task, yet would provide a test-bed for some of our ideas.

A single symbol learning strategy can be used to learn all types of visually perceived symbols such as weather symbols, electronic symbols, the Morse code, Navy signal flags, acronyms, and abbreviations. The formats and directions used in presenting information, exercises, and tests on weather symbols can also be used with electronic symbols or Morse code sight patterns.

The symbol learning strategy we are using is the TAEG algorithm for identifying symbols. It appears in the Interservice Procedures for Instructional Systems Development (1975) and in TAEG Report No. 23, Learning Guidelines and Algorithms for Ten Types of Training Objectives (Aagard and Braby, 1976). Formats for presenting training information on symbols have been developed which carry out the intent of the algorithm. General purpose computers are used to store the generic formats and automate the writing of the training materials. With this system, a human author enters information about a set of symbols into a data base. This data base is far simpler to write (and there-

fore less expensive) than the writing of a full text. The computer takes over at this point, which is possible because the formats of this kind of text are in many ways repetitive. A computer routine merges the contents of the data base with the generic formats and automatically organizes and prints a complete learning package, from title page to index (see figure 1).

What follows is a description of the computer-aided authoring technique for generating symbol learning materials. In addition, three related issues are discussed. The first concerns the training effectiveness of computer-authored training materials; the second is on the cost-effectiveness of authoring materials in this manner; the third deals with what can reasonably be expected from computer authoring (i.e., can we expect a computer to author materials to support major areas of the curriculum, such as teaching procedures, classifying targets or tactical decisionmaking).

DESCRIPTION OF TECHNIQUE

There are six steps in our current form of computer-aided authoring (see figure 2).

In step 1, the human author supplies the information called for in an author's workbook. Information required includes the title, authors, publisher, publication date, training objective, a statement describing the importance of knowing the specific set of symbols, and the examples of how the symbols are used. The author then compiles a table containing each symbol, its meaning, and a simple memory aid (see figure 3). In step 2, this information is keyed or scanned into computer memory. At this time the computer routines create the data base and compose all the pages in the instructional package (steps 3 and 4). Included are introductory pages, symbol discrimination drills, presentation of symbols and meanings, drills for recalling symbols, self-tests, criterion tests, and suggestions for refresher training. This is fundamentally different from manual word processing in that the computer automatically pulls data out of the data base and organizes it into pages. These computer routines adapt to a wide range of symbol types and sizes.

In step 5 each page can be displayed on the CRT and reviewed for accuracy, appropriateness of layout, and flow of information. When there is a need to edit the computer composed pages, four ways are available to change the material:

- edit the individual pages displayed on the CRT
- edit the data base and rerun the program
- edit the computer program (change standard headings, margins, etc.) and rerun the program
- make pencil changes to a computer produced manuscript and retype manually.

Editing is an optional step, in that you could produce the master copy for reproduction at this time without further review.

When the electronically stored pages are in an acceptable form, the document is printed (step 6) onto paper by the use of a line printer, computer driven typewriter, or phototypesetter. If a direct microfiche output is

required, or if graphic symbols are included, the phototypesetter should be used. Also, the phototypesetter makes it possible to use two or more fonts of type on a page. This process is described by Braby, Parrish, Guitard, and Aagard (1978).

The automatic authoring software was developed using a WANG 2200VP minicomputer system, a programmable calculator. This hardware was used because it was available. The central processor contains 32K bytes of main storage. This small amount of main storage made it necessary to use program overlays extensively in developing the software. All software is written in WANG Basic which is an extended revision of Dartmouth Basic (Guitard, 1978). While the WANG 2200 is probably not the best hardware to use for such an endeavor, the Basic-2 language available with the WANG 2200VP may be. WANG Basic-2 has extensive capabilities for manipulating alphanumeric strings. The equipment we are using is shown in figure 4. The software can be adapted for use on the text processing, composing, and typesetting equipment planned for the Naval Education and Training Command (Keeler, 1977).

EFFECTIVENESS IN SUPPORTING LEARNING. Obviously, anything that can be written by a computer routine can also be written by a human author. The question is: Can we devise a way to present information that optimizes learning and at the same time is machine producible?

We put this question to the test by comparing computer composed materials with traditional materials used in teaching Morse code (Ainsworth, 1979). The study was conducted with 160 students in the Signalman "A" School, Orlando, Florida. Four types of instructional material were compared.

- Traditional Materials consisted of a set of flash cards and a six page study guide containing the code and simple exercises. Students were expected to develop their own study methods. This was the approach used by the school in teaching the code.

- The Mnemonics Only Handbook contained graphic memory aids for the letters and other types of memory aids for numbers and punctuation marks. The 13 page booklet contained no practice exercises or self-tests.

- The Guided Practice Handbook presented the Morse code in six sets. Practice exercises and self-tests were included. Mnemonics were not included. This 137 page handbook was produced with the computer-aided authoring routines.

- The Guided Practice with Mnemonics Handbook was similar to the Guided Practice Handbook but also included the memory aids from the Mnemonics Only Handbook. Computer-aided authoring routines were used to produce this material. Sample pages from SYMBOL SET #2 are included as figure 5. In this example, the computer output was edited, and the graphic symbols were added by hand.

The intent was to determine the differential effects of aptitude, type of instructional material and amount of study time on the acquisition of Morse code. A 2x4x3 repeated measures design was used, involving two levels of aptitude, four types of instructional material, and three periods of study. The results for 4 hours of study are shown in figure 6.

In Morse code receiving is more difficult to learn than sending. Students who studied receiving Morse code with the two types of handbooks produced with computer aids learned significantly better ($p < .01$) than the students who studied with the traditional materials. Similarly students who studied sending Morse code learned significantly better ($p < .01$) with the Guided Practice With Mnemonics Handbook (a computer-generated document) and the Mnemonics Only Handbook.

The overall results indicated that the handbook produced with the full use of the computer-aided authoring routines (Guided Practice With Mnemonics) was superior to the other approaches. This handbook essentially eliminated performance differences between the average and above average groups. After 4 hours of study using the computer authored text with mnemonics and guided practice, the combined score (for sending and receiving) was 93% for the average group and 96% for the above average group. When traditional materials were used there was a large difference in performance between the two groups. The combined score for the average group was 75% and 89% for the above average group. (Students in the average group had scores between 99 and 114 on the Word Knowledge and Arithmetic Reasoning subtests of the Armed Services Vocational Aptitude Battery (ASVAB). Students in the above average group had scored between 115 and 143 on these tests.) As the result of this evaluation, the Guided Practice With Mnemonics Handbook has been adopted by the Navy Signalman Schools, and all new signalmen will use it in their study of Morse code.

Clearly our computer authoring routines worked well in this particular case. The results indicated the feasibility of using computer-aided authoring routines for producing effective instructional materials for symbol recognition.

COST EFFECTIVENESS. Computer authoring can work well but at what cost? The use of computer-aided authoring appears to be a low cost way of producing these materials, but the facts are not all in. We are currently preparing a report that discusses the costs and compares them with the cost of the traditional labor intensive way of authoring these materials. Our observations to date include the following.

1. Creating the data base is a relatively simple and inexpensive task.

2. Once the data base exists, it takes less than 5 minutes of machine time to produce a 100 page book.

3. Proofreading, changing text, and retyping with the computer-aided system saves hours of production time. For instance, once the information in the data base is spelled correctly, the computer generated handbook will contain no typographical errors or misspelled words.

BROAD USE IN CURRICULUM DEVELOPMENT. Can computer-aided authoring routines support major curriculum areas? We are attempting to find the answer to this question. It seems reasonable to expect that computer routines will be of real value in authoring materials with high levels of redundancy, such as found in technical training materials. These training materials often present the same information in overviews, descriptions, self-tests, summaries, criterion tests with answers, and refresher training guides. In addition, standard writing and presentation formats are used repetitively in these materials. These content and format redundancies are not found in most other types of writing.

TAEG is now designing computer-aided authoring routines for material to teach equipment operation and maintenance procedures to be performed from memory. We are well into this task. It involves extensive use of digitized line drawing and photographs as well as alphanumerics and is a logical extension of our work with symbols. If successful, these routines could support major segments of the Navy's "A" and "C" schools curricula and may support the production of some types of job performance aids.

Other types of job tasks being considered are classifying/recognizing patterns, rule using, tactical decisionmaking, recalling bodies of knowledge, and voice communicating.

READABILITY EDITING. Another aid to the author being developed by TAEG is a readability editing system (Kincaid, 1978). While this is a separate system, it will be used in editing the data base in the computer-aided authoring system. This system is being developed for use in writing centers with computer processing capabilities. As draft training material is computer processed, much useful feedback is provided the technical writer and his editor for revising drafts. There are three components to the system:

1. A feature to flag "uncommon" words. These are defined as those not on a list of 1,900 common words which was compiled by a frequency analysis of 240,000 words of recruit training material.

2. The calculation of grade level of readability according to the Department of Defense readability formula (Kincaid, Fishburne, Rogers, and Chissom, 1975).

3. A word and phrase substitution feature. Awkward phrases such as "in accordance with" are flagged and substitutes such as "according to" are suggested.

A computer printout incorporating each of these features is almost immediately available to the technical writer. Perhaps the most useful feature of the system is that glossaries can be compiled based on the uncommon words that are flagged.

POSTNOTE

The results of the computer-aided authoring study to date have been impressive. The use of computer aids appears to be an effective and low cost way of producing training materials. But this is just the beginning. Evidence is mounting that basic instructional design processes can be automated, and it now appears feasible to develop these computer-based authoring aids to support the performances required in a broad range of job tasks.

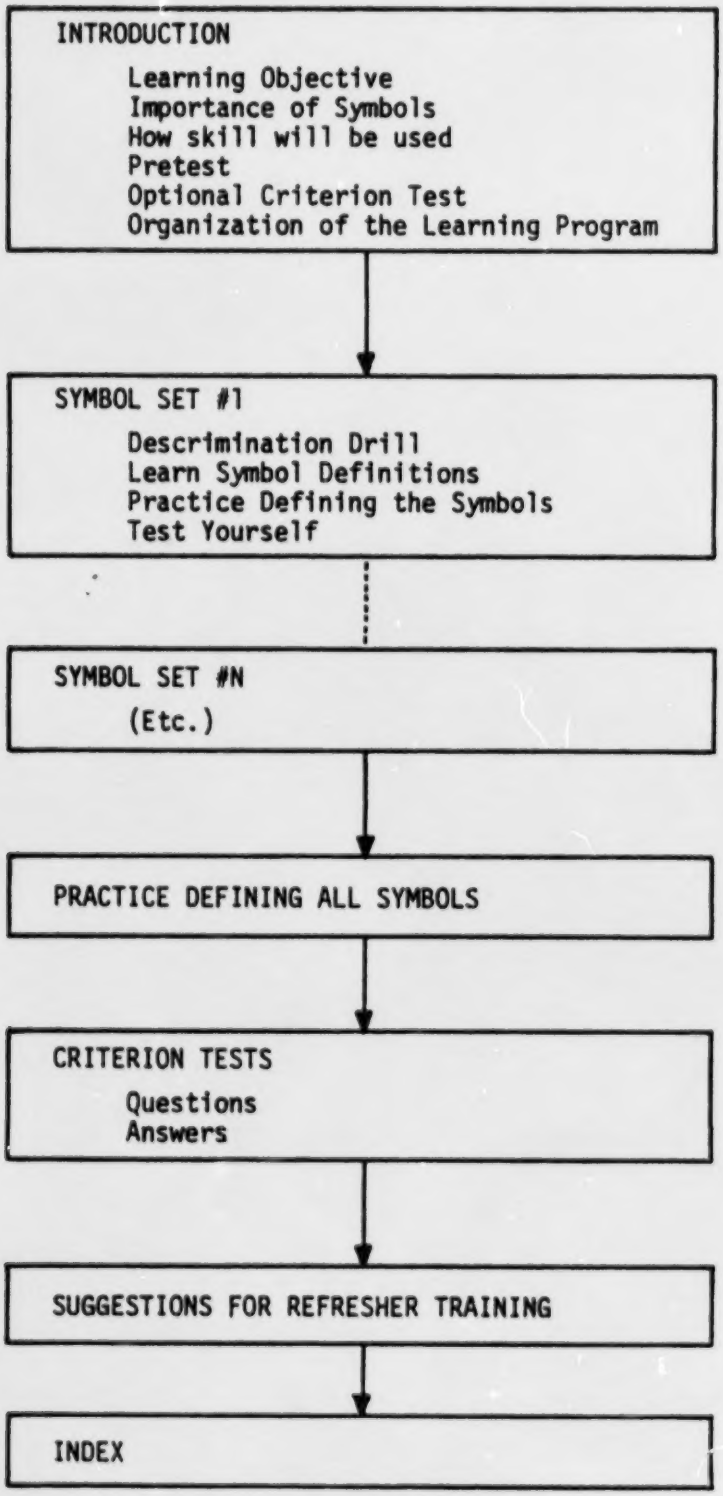


Figure 1. The Sequence of Page Formats Used in the Programmed Texts

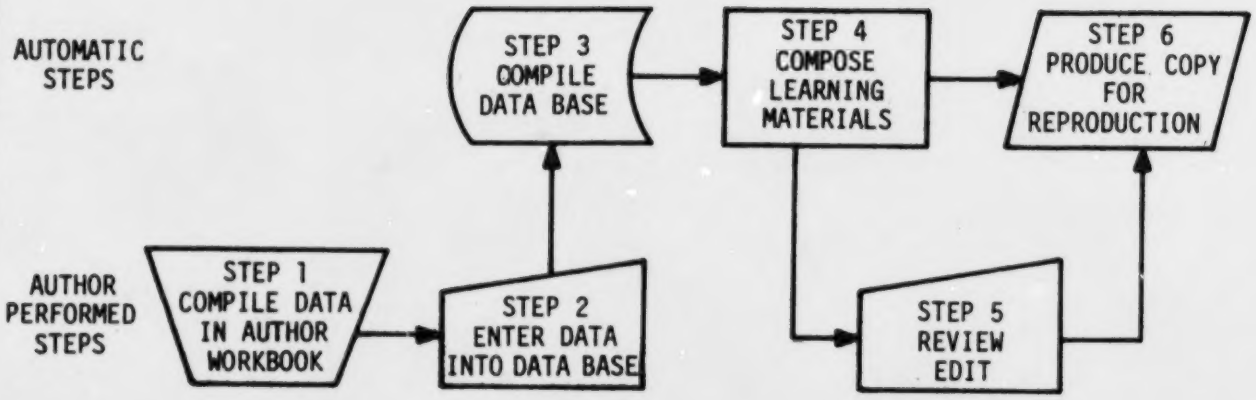

AUTOMATIC STEPS
AUTHOR PERFORMED STEPS
STEP 1 COMPILE DATA IN AUTHOR WORKBOOK
STEP 2 ENTER DATA INTO DATA BASE
STEP 3 COMPILE DATA BASE
STEP 4 COMPOSE LEARNING MATERIALS
STEP 5 REVIEW EDIT
STEP 6 PRODUCE COPY FOR REPRODUCTION

Figure 2. Steps in the Use of the AUTHOR Program

An Automatic Authoring System - Data Entry Workbook

This workbook outlines the information that you, the author, must supply to create an instructional module for teaching symbol recognition. In providing this information, follow the directions carefully. Record your information in the spaces provided.

1. Enter the following information for the title page:

   1.1 ** Title: BASIC EXERCISES IN MORSE CODE

   Max: 2 lines, 45 characters per line.

   1.2 Subtitle: _____

   Max: 2 lines, 50 characters per line.

   1.3 ** Author(s): RICHARD BRABY
   JAMES AINSWORTH

   Max: 4 lines, 50 characters per line.

   1.4 Date wanted on title page: JANUARY 1979

   Max: 1 line, 50 characters per line.

   1.5 ** Organization producing the program: _____
   SERVICE SCHOOL COMMAND,
   ORLANDO, FLORIDA 32813

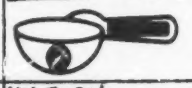
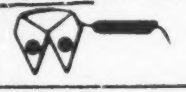
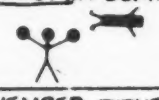
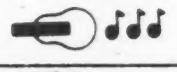
   Max: 2 lines, 50 characters per line.

2. ** Record your learning objective(s): AFTER COMPLETING THIS PROGRAM YOU WILL BE ABLE TO WRITE MORSE CODE EQUIVALENTS OF LETTERS, NUMBERS, AND PUNCTUATION MARKS

** See section 2.0 of this report for special formatting techniques.

Figure 3. Sample Pages from the AUTHOR Workbook

AUTHOR: An Automatic Authoring System Data Entry Workbook: Symbols

SET	SYMBOL #	SYMBOL	DEFINITION	MEMORY AID	SIMILAR SYMBOLS
2	1	.—	A	ALPHA-ALPHABET SOUP 	
	2	..—	U	UNIFORM-INSIGNIA 	
	3	...—	V	VICTOR IN BOXING 	
	4	—.	N	NOVEMBER- TURKEY	
	5	—..	D	DELTA-JET AND 2 CLOUDS	
	6	—...	B	BRAVO! PLAY 3 NOTES AGAIN 	
	7	..——	J	JULIETT	
3	1	.—-.	P	PAPPA'S- EARS AND EYEBROWS	

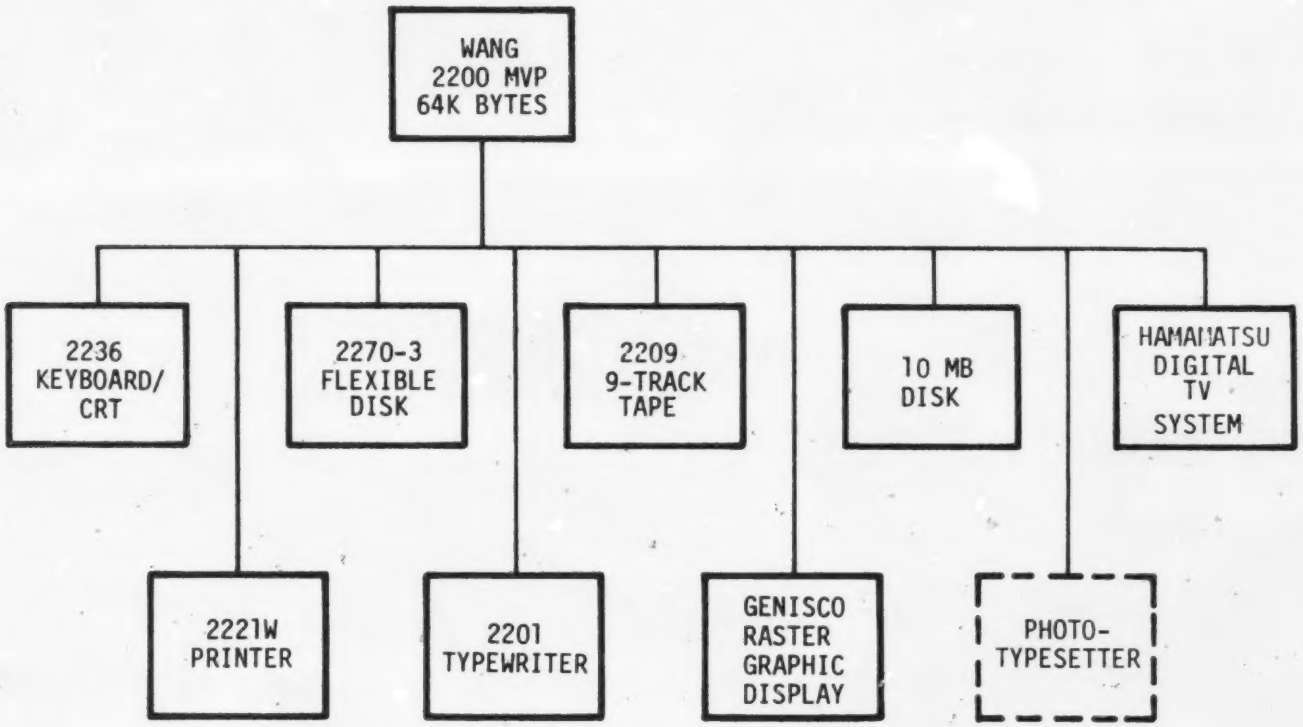
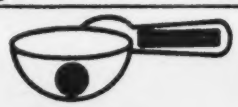


Figure 4. Hardware in the Computer-Aided Authoring Systems

SYMBOL SET #2: LEARN SYMBOL DEFINITIONS 18

Definition	Memory Aid	Symbol
A	ALFA - alphabet soup 	.-
U	UNIFORM insignia	..-
V	VICTOR in boxing	...-
N	NOVEMBER turkey	-.
D	DELTA jet and 2 clouds	-..
B	BRAVO! Play 3 notes again!	-...
J	JULIETT	.---

Go to 19

Figure 5. Sample Pages from the Guided Practice With Mnemonics Handbook for Morse Code

SYMBOL SET #2: PRACTICE DEFINING THE SYMBOLS 21

Directions

1. Read all directions before you practice.
2. On page 22, recall the Memory Aid for each Morse Code symbol in the "Practice Symbols" section. Then recall the letter associated with that code. WRITE the letter on scratch paper.
3. CHECK your answers after writing them down. The answers are below the practice symbols.

Go to 22

Figure 5. Sample Pages from the Guided Practice With Mnemonics Handbook for Morse Code (continued)

SYMBOL SET #2: PRACTICE DEFINING THE SYMBOLS 22

Practice Symbols

-. ..- .- -... .--- ...-

...- -.. ..- .- -. ...-

-... .--- ...- -.. -... -.

-.. .--- ...- -. .- ..-

..- -... ...- -. ..- .---

Answers

.---	J
...-	V
-..	D
-.	N
.-	A
..-	U
-...	B

Go to 23

Figure 5. Sample Pages from the Guided Practice With Mnemonics Handbook for Morse Code (continued)

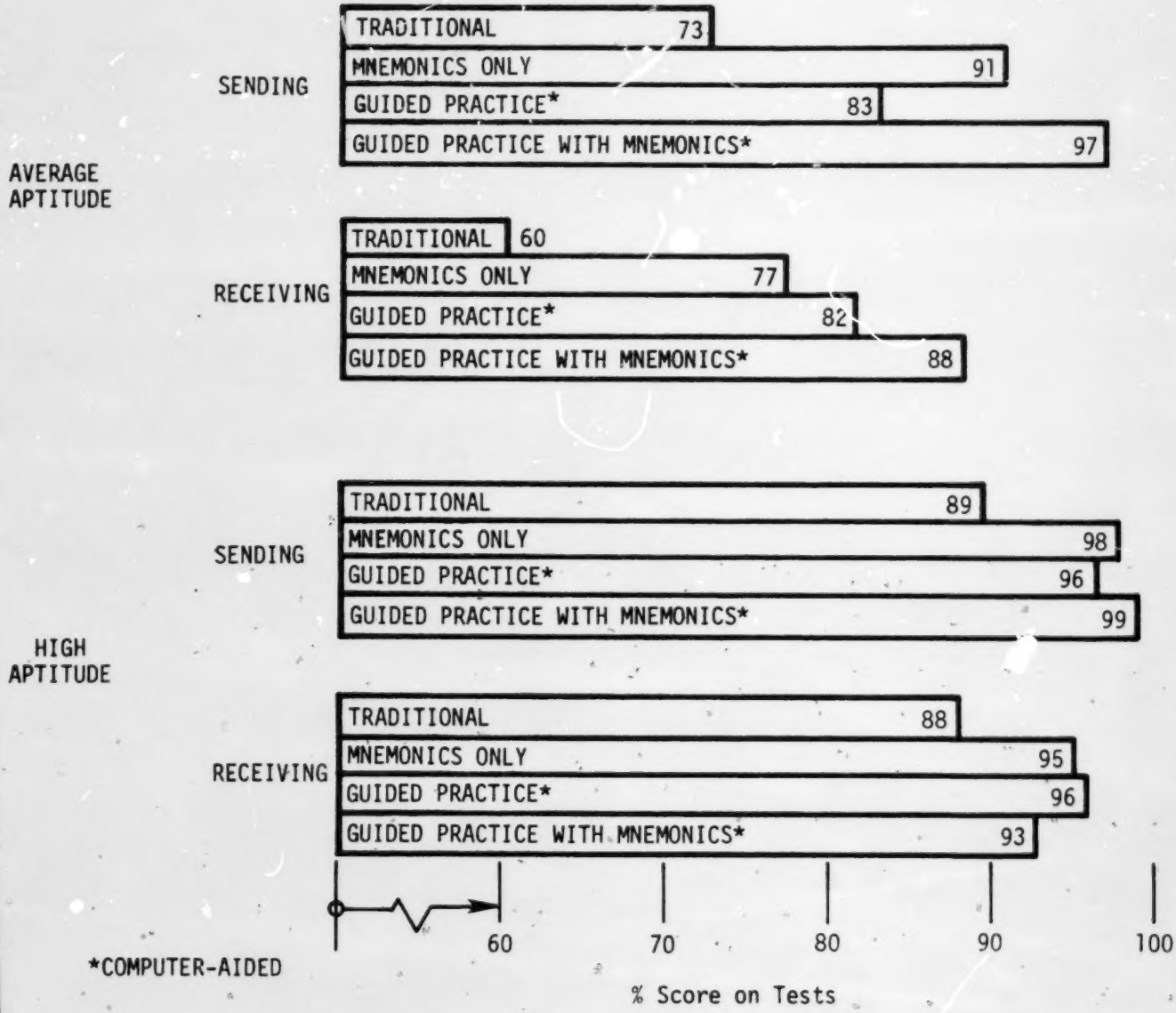


Figure 5. Performance of Average and High Aptitude Students on the Sending and Receiving Tests After Four Hours of Practice (four training packages are shown)

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